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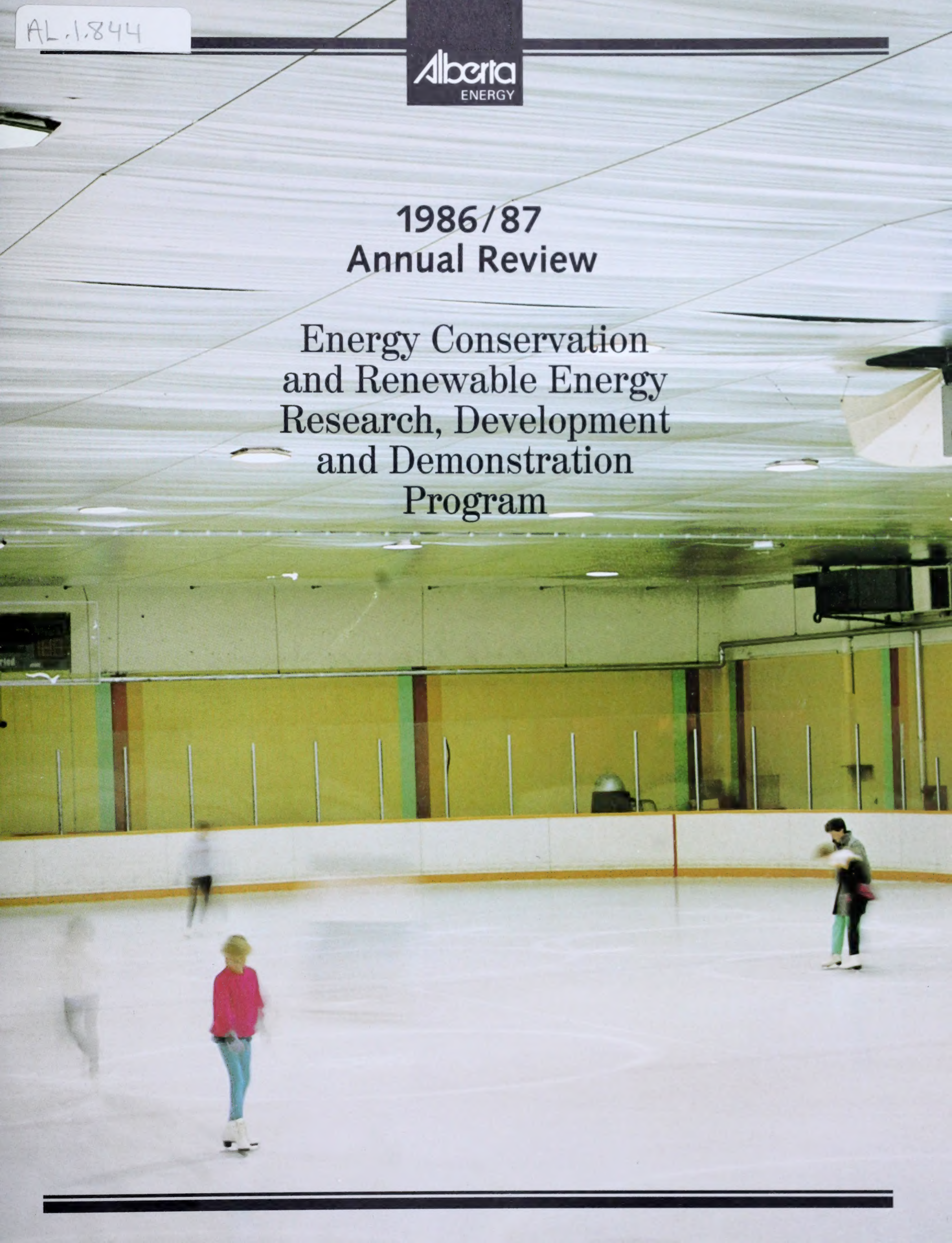

1986/87
Annual Review

Energy Conservation and Renewable Energy Research, Development and Demonstration Program

Cover Photo: A low emissivity ceiling, installed at the Londonderry Arena in Edmonton, has substantially reduced the transfer of radiative heat from the warm ceiling to the cold ice surface, resulting in a reduced demand for refrigeration energy. The extent of energy savings is being monitored for one year; preliminary results suggest there is considerable potential for this concept throughout Alberta.
Photo by Ian Biggar; courtesy of Edmonton Parks and Recreation Department.

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Energy Conservation and Renewable Energy Research, Development and Demonstration Program

Alberta
ENERGY
Scientific and Engineering
Services and Research Division

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Director's Report

The importance of energy conservation and renewable energy to Alberta's overall energy situation continues to be recognized and supported by the Alberta/Canada Energy Resources Research Fund (A/CERRF).

This support is reflected in the Energy Conservation and Renewable Energy Research, Development and Demonstration Program, which began in 1977 with research projects focusing on solar and wind energy. Since then, 65 research, development and demonstration projects have been supported on such topics as geothermal energy, fusion energy, energy conservation in buildings, waste heat recovery and general energy conservation. Beginning in 1983/84, the program's emphasis shifted to three subjects, each of which became a separate subprogram area.

These subprograms are:

Energy Conservation in Buildings

Wind Energy

Waste Heat Recovery/Low Temperature Heat Utilization

At the end of 1985/86, 36 projects were underway in these three subprograms. Twenty-two were completed this year, three were terminated and 11 are scheduled for completion next year or later. Funding contributions from A/CERRF amounted to $422 422.

The technology transfer and dissemination project, which began during the last quarter of 1985/86, was responsible for raising the profile of the program and led to some suggestions for future projects.

Energy Conservation in Buildings

Fourteen projects were active this year, one was terminated and final reports were received for another 12 projects that were completed in the last quarter of 1985/86. Five projects will be carried over into 1987/88. There were several noteworthy accomplishments this year. For example, an insulating curtain that attaches to the outside of overhead doors, and was designed and built in Alberta, was demonstrated at a City of Calgary warehouse. It caused a 25 per cent decrease in natural gas consumption. It was also found to be twice as effective as weatherstripping in reducing air leakage around overhead doors at only slightly greater cost. The designer is now attempting to market the product commercially.

In a related development, a control device that prevents warehouse heaters from switching on as long as overhead doors are open, encourages people to close the doors during cold weather. Its use in small warehouses resulted in improved energy efficiency; by as much as 50 per cent in some cases. This device, too, is being marketed.

The last of three residential furnace projects was completed this year. In this investigation, it was found that many of the reported problems with higher-efficiency furnaces were caused by improper installation, although some were caused by deficient designs. The survey information was made available to manufacturers and installers to help them improve their products and services.

Architects who wish to incorporate solar energy collection and storage systems into the structure of buildings can use a newly developed computer model, called "ActPas," in their design considerations. The software for ActPas is available from the University of Calgary.

One project that is continuing into 1987/88, is demonstrating the value of using low emissivity ceilings in ice arenas. By installing an aluminized ceiling material that reduces the amount of radiant energy reaching the ice surface from the roof area of the arena, refrigeration energy requirements in two test arenas have been lowered and might be reduced by as much as 33 per cent. If early indications are confirmed by an ongoing monitoring program, up to $3 million a year could be saved by the use of such ceilings in all indoor ice rinks in Alberta.

Wind Energy

Within the Wind Energy subprogram, one project was completed this year and the final report of the Solar and Wind Energy Research Program (SWERP) was received.

Development of a 16-m (50-ft.) diameter wind turbine was completed this year. During a fully instrumented testing period, the prototype's coefficient of performance was found to be almost identical to the value predicted from wind tunnel testing of scale models.

The prototype began pumping water at very low wind speeds (2.2 m/s; 5 m.p.h.) and showed it was capable of pumping water at the rate of 500 L/s (6 600 gal./min.), depending on the pumping head. A smaller wind turbine, based on the same design, was tested at the Lethbridge Wind Research Site. Preliminary results indicate that its performance may well exceed that of all other wind turbines tested previously at this facility. The contractor has begun to market the smaller model.

The results of ongoing investigations at the Lethbridge Wind Research Site continue to be valuable to wind turbine manufacturers and customers. Eight wind turbines and two solar-powered water pumpers were tested this year using a new data acquisition system and a revamped pump station. It is becoming apparent that turbines and the water-pumping systems supplied by manufacturers are not well matched. This is responsible in part for the limited efficiency being achieved with most of these machines.

Waste Heat Recovery/Low Temperature Heat Utilization

Seven projects were underway this year in the Waste Heat Recovery/Low Temperature Heat Utilization subprogram. Two were terminated. Among the five projects that are continuing, preliminary results from an investigation at Lakeside Packers are especially promising. A waste heat recovery system that captures heat from the refrigeration system and uses it to heat water used in the abattoir was designed and built. Twenty-four per cent of the waste heat is being recovered as expected, but the slaughtering process is also experiencing less downtime than in the past. This is an unanticipated bonus. The waste heat recovery concept used in this project is equally applicable in breweries and in plants that process vegetables, poultry and other food products.

Two projects are focusing on the prospects of using co-generation to simultaneously generate electricity and produce recoverable heat. Preliminary results are encouraging and are especially appropriate because of increasing interest in various forms of parallel electricity generation.

Technology Transfer and Dissemination

This year, hundreds of energy researchers, architects, designers and energy specialists received technology transfer booklets that describe various energy conservation and renewable energy projects completed in previous years. Nine booklets covering 24 projects were published and distributed.

Program Overview

In summary, the Energy Conservation and Renewable Energy Research, Development and Demonstration Program is continuing to help Albertans save energy and develop alternative energy resources. Along the way, the program is also helping innovators and entrepreneurs establish themselves as providers of services and products that one day may make a distinct contribution to Canada's overall energy scene.

J. K. Kleta
Director
Energy Conservation and
Renewable Energy Research

Introduction

Funding for the Energy Conservation and Renewable Energy Research, Development and Demonstration Program is provided through the Alberta/ Canada Energy Resources Research Fund (A/CERRF). Contractors who perform the actual research work also make financial contributions to individual projects.

A/CERRF was established as a result of the 1974 agreement on oil prices between the federal government and the producing provinces. The federal government pledged increased funds to strengthen and diversify Alberta's economy, including $96 million for energy-related research projects. Responsibility for applying and administering the fund rests with the A/CERRF Committee, comprising senior Alberta and federal government officials.

During 1986/87, research activities continued to focus on three main research areas, namely:

Energy Conservation in Buildings

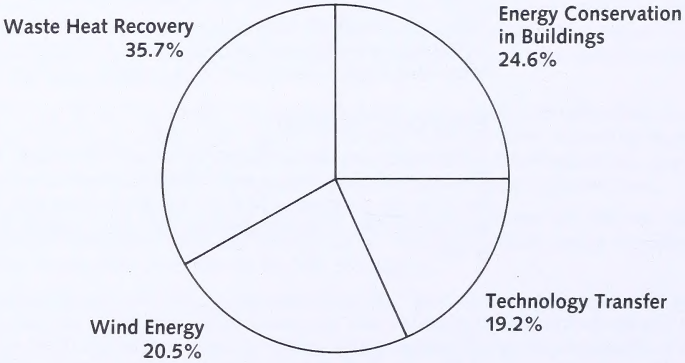
Wind Energy

Waste Heat Recovery/Low Temperature Heat Utilization

The following section, Review of Program Projects — 1986/87, provides detailed information about individual projects and their achievements, while the financial aspects of past and present projects can be found in Appendix A.

The portion of program expenditures provided by A/CERRF this year amounted to $422 422. It was divided among the three subprogram areas and technology transfer as shown in Figure 1.

Figure 1: A/CERRF Energy Conservation and Renewable Energy Program Funding Distribution (1986/87)



	Funding ($)	Percentage (%)
Energy Conservation in Buildings	103 989	24.6
Wind Energy	86 716	20.5
Waste Heat Recovery	150 514	35.7
Technology Transfer	81 203	19.2
TOTAL	**422 422**	**100.0**

Review of Program Projects – 1986/87

The following project summaries describe the objectives and principal results of investigations partially funded by A/CERRF and carried out during 1986/87 in the Energy Conservation and Renewable Energy Research, Development and Demonstration Program. For additional information, contact the Director of Energy Conservation and Renewable Energy Research or the appropriate contractor(s).

Energy Conservation in Buildings

Energy consumption in building systems accounts for approximately 35 per cent of Canada's energy demand. Whether this energy is used to heat our homes in winter, cool our office buildings in summer or allow us to ice skate indoors year-round, it can be reduced substantially if heat losses are minimized, alternative cooling methods are tried and innovative energy-saving ideas are adopted.

Such are the goals of the *Energy Conservation in Buildings* subprogram, that has supported 38 research, development and demonstration projects so far. Fourteen are described in the following section; final reports were received for 12 projects completed last year and one of this year's projects that was terminated. Those project reports which are available for viewing at the Alberta Energy Library* are:

Edmonton Energy Conservation Centre

A Survey of Air Leakage in Alberta Homes

Construction and Testing of a Masonry Module

Seasonal Efficiency of Residential Natural Gas Furnaces

Programmable Controller for Parking Lot Block Heater Service

Demonstration of a Cost-Effective Energy Management System

* see Appendix B

Energy-Efficient Housing Display Program

Alberta Home Builders' Association (formerly HUDAC), Edmonton

The heating fuel consumption of 10 energy-efficient show homes (two of which are shown here) was monitored for several years and found to be approximately 38 per cent below that of standard homes not equipped with energy-saving features.

In 1981, 10 energy-efficient homes were built in Edmonton and Calgary (five in each city). Since then they have been sold and occupied. For two heating seasons, prototype digital monitoring equipment was used to measure and record the energy consumption performance of the houses, but difficulties arose with recording and interpreting the information; this approach was abandoned. Subsequently, heating and electricity bills for the 1982-1986 period were obtained for each house and this information was analysed by using the HOT-2000 computer program developed by the National Research Council and Energy, Mines and Resources Canada.

When compared with how the houses might have performed had they been built to conventional building and insulation standards prevalent in 1981, it was found that fuel savings of 11 to 57 per cent (averaging 38 per cent) resulted from the various combinations of energy-conserving features that were added to these homes.

While it is not possible to determine how these results were influenced by the energy-consuming habits of individual owners, the project nevertheless demonstrated that substantial savings are possible.

Although the energy-conserving features of these homes have been superseded in recent years by more energy-efficient designs, this project helped Alberta home builders become more aware of energy efficiency and contributed to the acceptance of R2000-type dwellings in Alberta.

The project has been completed.

Energy Savings and Payback of Retrofit Basement Wall Insulation

Dow Chemical Canada Inc., Edmonton/Toronto

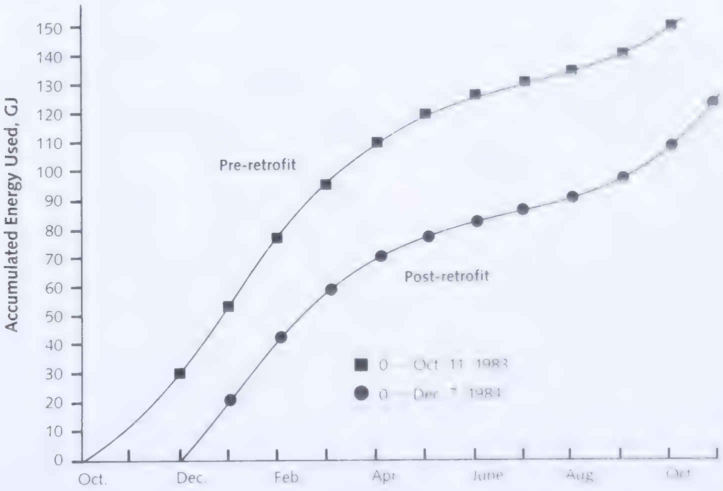
To compare the energy savings available by insulating either the inside or outside of basement walls, the contractor applied different insulation materials to five existing, owner-occupied homes (four in Edmonton; one in Calgary). For one year after insulating, home heating costs were compared with those of the previous year. Insulation materials that were used included expanded polystyrene, extruded polystyrene, fibreglass batts and semi-rigid fibreglass.

Retrofits, all of which were done by building contractors, ranged in cost from $3 200 to $4 600 and resulted in fuel cost savings of $68 to $233 a year. This represents energy savings of 10 to 24 per cent, with payback periods of 13 to 68 years. It was noted, however, that the payback periods could be reduced substantially if homeowners did their own work.

In a parallel study using unoccupied housing modules at the Alberta Home Heating Research Facility, it was shown that below-grade heat losses can be reduced by approximately 60 per cent when rigid polystyrene sheathing (RSI 1.76, R 10) is applied to the exterior of basement walls. Consequently, the potential for significantly lower heat losses, and the added comfort made possible by higher levels of insulation, warrant the addition of basement wall insulation to new homes while they are under construction.

The project has been completed. The final report is available for viewing at the Alberta Energy Library (see Appendix B).

Normalized Energy Usage



Typical energy performance data for a test home, before and after basement insulation

(Source: *Energy Savings and Payback with Basement Wall Insulation Retrofit*, D.S. Greeley, Dow Chemical Canada Inc., December 1986)

Retrofit Wall Systems for Residential Housing

ARE–Alternative & Retrofit Energies Inc., Calgary

Over a two-year period, the contractor, using input from builders and materials suppliers, evaluated 15 wall insulation systems that can be retrofitted to the exterior, above-ground walls of standard, detached housing to achieve better airtightness and a higher level of insulation. Each system was ranked according to its ability to satisfy 52 criteria covering such aspects as insulation properties, costs and installation characteristics. Retrofit wall systems were subdivided into three classes: rigid sheathing, curtain wall and spray-on.

Overall, expanded polystyrene sheathing was found to be superior. The TEC curtain wall system (attached to and built out from existing exterior walls) was a close second, but others might be suitable depending on the particular retrofit circumstances. Based on this investigation, the contractor outlined the most desirable features of an ideal retrofit wall insulation system.

The project has been completed. The final report is available for viewing at the Alberta Energy Library (see Appendix B).

Desirable Properties of an Ideal Retrofit Wall System

a) have as high an R-value as possible
b) act as an air barrier
c) not retard vapour movement
d) allow direct application of stucco
e) be capable of sculpturing
f) achieve RSI 4.2 (R24) in only one layer
g) be produced from biodegradable materials
h) provide a continuous thermal break
i) not degrade under ultraviolet light
j) not be the source of any health risks
k) be capable of application in any weather condition.

(Source: *Retrofit Wall System for Residential Housing,*
ARE–Alternative & Retrofit Energies Inc., 1986)

Residential Air-to-Air Heat Exchanger Using Heat Pipe Technology

EMC Energy Management Consultants Ltd., Calgary

Heat pipe technology developed for the aerospace program has proven to be an effective and reliable method of heat transfer and could have down-to-earth applications in airtight homes. Four prototype air-to-air heat exchangers using this technology were designed and built to determine whether they offered advantages over conventional systems. Two units were eventually rejected, but one was installed in an airtight Calgary home and monitored, while another was sent to the Ontario Research Foundation where its air flow rates, cross-leakage and efficiency were tested.

Although the heat recovery capability was found to be less than anticipated and the expense of importing the heat pipe core led to the conclusion that the unit did not offer any cost or energy-saving advantages over conventional designs, the system still possesses a number of advantages over products now on the market. For instance, it occupies less space, has few moving parts, is easily cleaned and maintained, and can be used to provide some cooling during warm weather. The unit installed in the airtight home performed well and pleased the homeowners.

The project has been completed.

Survey of Energy-Efficient Furnaces

Howell Mayhew Engineering Inc., Edmonton

Since the introduction of medium- and high-efficiency furnaces by several manufacturers, some homeowners have reported dissatisfaction with this equipment because of corrosion, high maintenance costs and high indoor moisture levels. To better define the problems that have arisen in Alberta and to propose some solutions, a survey was made of Alberta furnace distributors, furnace owners, heating contractors, regulatory agencies, utilities and researchers involved in furnace development.

The survey covered nearly 600 reports of problems involving higher-efficiency furnaces in Alberta. Approximately 58 per cent of the problems were related to furnace shutdown caused by failure of components and 16 per cent were the result of improper installation by heating contractors who did not follow manufacturers' instructions.

The project contractor noted that certain design features are being corrected by individual manufacturers. Homeowners and installers must accept the fact, however, that higher-efficiency furnaces are more complex than conventional furnaces and, therefore, heating contractors need to become better trained in installation procedures; also, homeowners should resist tinkering with these types of furnaces. The project was completed.

Highlights of this and three other furnace projects completed in previous years are described in the technology transfer booklet, *Performance Characteristics of Energy-Efficient Residential Furnaces.*

Development of a Computer Program for Analysis of Thermal Mass in Buildings

The University of Calgary, Calgary

The ActPas computer model was used to design the solar storage wall used in the Sandstone Valley Ecumenical Centre, Calgary. Architects: Tang Lee and Richard Sandi.

Some researchers believe solar energy could become a significant factor in Canada's energy picture over the next 20 to 30 years if solar collectors and storage subsystems are integrated into the structure of buildings, thereby using the mass of each building as a heat storage and/or transfer medium. Of the various designs that could be incorporated into building-integrated concepts, two that can be cost-effective were evaluated in detail in this study. They were: (1) direct gain, passive systems and (2) air-based, open circulation, active charge-passive discharge designs.

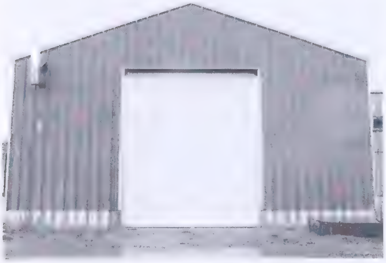
Numerical models of each system were developed. They evolved into "ActPas," which is a computer simulation of active and passive systems that can be used with a high degree of accuracy as a design aid. It is particularly useful in making decisions as to the suitability of various building-integrated solar systems.

ActPas software, written for IBM-compatible microcomputers, is available at a nominal cost from the contractor. (Subsequent to this study, a revised and more accurate model was developed. The software and a manual are available from Tang G. Lee, Faculty of Environmental Design, The University of Calgary, 2500 University Drive N.W., Calgary, Alberta T2N 1N4)

The project has been completed. The final report is available for viewing at the Alberta Energy Library (see Appendix B).

Retrofit Curtain for Overhead Doors

Appropriate Technology, Calgary



One of two retrofit curtains used on the overhead doors of a City of Calgary warehouse.

An insulating curtain, which is made from reinforced polyester fabric and can be attached to the outside of overhead doors, was designed, built and tested in Calgary. After two full-scale curtains were installed over the doors of a Calgary warehouse, gas consumption decreased by an average of 25 per cent. This occurred because there was less air leakage around the door, but also because the fabric, which transmits solar energy, transformed the door into a solar collector and allowed warm air to be supplied to the warehouse by convection. Because the curtain permits air sealing around all four edges of the door, it is twice as effective in reducing air leakage as weatherstripping and only slightly more expensive. A three-year payback period is projected for most applications.

A market survey indicated 70 per cent of existing shipping doors in Alberta can be economically retrofitted with this curtain. The contractor decided it should be marketed through overhead door distributors.

The project has been completed. It is described in greater detail in the technology transfer publication, *Control of Heat Loss Associated with Overhead Doors*.

A New Heat-Conserving Control System for Warehouse-Type Buildings

Camcon Controls Ltd., Calgary

Interior of a Master Tune outlet in Calgary showing an overhead door and a ceiling-mounted heater. Con-Serve Heat Sentry controller, mounted on the wall (left) is activated when either of two overhead doors opens.

In a typical warehouse, whenever overhead doors are opened during the winter, the cold air that enters will be sensed by thermostats and cause furnaces or heaters to switch on. If the doors are left open, substantial amounts of energy can be consumed as heaters compensate for the influx of cold air and try to maintain a fairly constant comfort level within the building.

Closing the doors and burning less fuel would be a better alternative, but experience shows that workers often fail to do this. Consequently, an electronic control system was devised (called the Con-Serve Heat Sentry) that interlocks with overhead doors and prevents heaters from switching on as long as the doors are open. To prevent a substantial decrease in the comfort level, the system uses programmable thermostats, timers and the fans inside heating units to make the best use of heat already present in a warehouse.

The system was installed in six Calgary warehouses and underwent improvement and testing for one year. At the end of the test period, fuel consumption was compared to fuel use before the system was installed, with suitable corrections for differences in outdoor temperatures from one year to the other.

For some types of warehouses, particularly small ones with one or two doors, use of the device resulted in improvements in energy efficiency of as much as 50 per cent, with a payback period of less than one year. In other cases, especially buildings with 20 or more overhead doors that are opened often, there was little or no improvement. It would appear the system can be a useful energy management tool in small warehouses, garages and service stations throughout Canada.

The project has been completed; highlights are described in the technology transfer publication, *Control of Heat Loss Associated with Overhead Doors.*

Energy Conservation in Public Swimming Pools

IBI Group, Calgary

Energy consumption and humidity levels are being monitored at the Renfrew Pool in Calgary to determine the effectiveness of an energy control system.

Following an energy audit of the Renfrew Pool, one of 11 City of Calgary public swimming pools, and the identification of measures that might be taken to reduce energy consumption at this facility, a heating, ventilation and air conditioning control system was designed and installed. A one-year monitoring program was begun to determine the effect of the control system on energy consumption, as well as humidity control, the latter having been shown to be important in preventing structural damage to the building. It is anticipated that many of the findings from the monitoring program will be directly applicable to pools throughout Alberta.

Swimming Pool Dehumidification Demonstration

Klass Mechanical Enterprises Ltd., Calgary

The structural integrity of buildings that house indoor swimming pools can be damaged by the high levels of humidity in the indoor air, and pool users often remark that the humid air makes them feel uncomfortable. To control humidity, the normal procedure is to expel indoor air to the outside and bring in fresh air from outdoors. An alternative would be to use a refrigeration-type dehumidification system from which waste heat might be recovered and used elsewhere in the building.

During the initial phase of this project, it was concluded that heat pump-type dehumidifiers can be cost effective in Alberta and could be used in high-use pools operated by municipalities, universities, hotels/motels and residential complexes. The contractor is comparing the performance of a conventional air exchange system with a heat pump dehumidification system at the University of Lethbridge Aquatic Centre, with particular emphasis on energy consumption and opportunities to use waste heat.

Demonstration of Low Emissivity Ceilings in Alberta Arenas

Sunton Engineering Ltd., Edmonton

Studies have shown that transfer of heat by radiation from the warm ceiling of an ice arena to the cold ice surface accounts for approximately 35 per cent of the daily load on the refrigeration system. By installing an aluminized ceiling material (having a radiative emissivity of four to five per cent versus 85 to 95 per cent for wood) above the ice surface, as has been done in some Ontario, Quebec and U.S. arenas, refrigeration energy requirements can be reduced by as much as 33 per cent.

Following detailed analysis of two ice arenas (one each in Edmonton and Medicine Hat), where payback periods of three and five years respectively were estimated, low emissivity ceilings were installed in both arenas and a one-year monitoring program to determine the effect on energy consumption was begun. Initial results have been encouraging. Soon after the ceilings were installed, less energy was consumed because a higher ice temperature could be maintained. It has been estimated that up to $3 million a year could be saved if all Alberta arenas began using low emissivity ceilings.

Low emissivity ceilings were installed at Londonderry Arena in Edmonton (shown here) and the Medicine Hat Civic Centre Arena. Initial monitoring results are showing lower energy consumption, with anticipated payback periods of approximately three to five years.

Demonstration of Free Cooling in Building Humidification Systems

Safronek, Pomeroy & Associates Ltd., Calgary

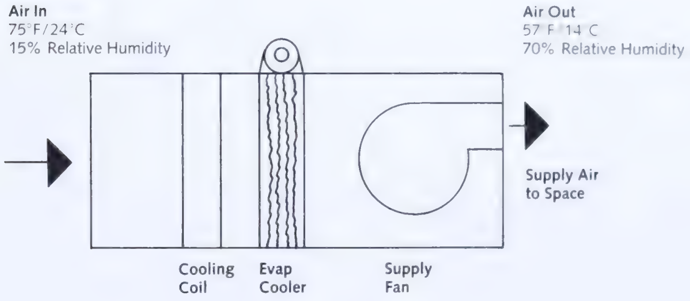
Under some atmospheric conditions, evaporation from water-soaked pads or water sprays can produce sufficient air cooling to achieve a comfortable indoor environment without the need for the refrigeration component of air conditioning systems. In this way, the refrigeration unit can be shut off under certain conditions and some energy saved. The contractor's investigations revealed that evaporative cooling is technically feasible throughout Alberta, and is especially applicable in southern Alberta because of the combination of air conditioning needs and atmospheric conditions. This resulted in a monitoring program being initiated at the University of Lethbridge.

Existing spray coil and cellulose media systems are being monitored to determine the number of days each year that evaporative cooling is effective. Results so far have been erratic and more extensive monitoring is required.

Schematic Comparison of Evaporative and Mechanical Cooling

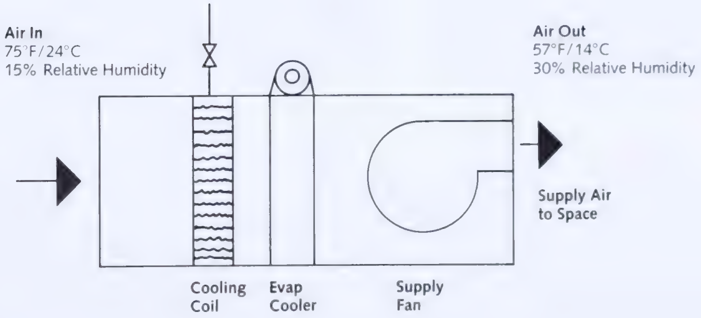
EVAPORATIVE COOLING
0.4 USGPM water evaporated per 10 000 CFM, including 50% blowdown.
(0.025 L/s per 4 700 L/s)

Room Conditions
72°F/22°C
45% Relative Humidity
(0.80 Sensible Heat Ratio)



MECHANICAL COOLING
16 Tons mechanical cooling required per 10 000 CFM
(56 kW per 4 700 L/s)

Room Conditions
72°F/22°C
22% Relative Humidity
(0.80 Sensible Heat Ratio)



(Source: Safronek Pomeroy & Associates)

Demonstration of Mini-Fluorescent Lighting

Clear-View Lighting Limited, Calgary

Mini-fluorescent lamp fixtures of the types shown here were satisfactorily demonstrated at five building locations, and should be regarded as suitable replacements for incandescent lamps in numerous applications.

With the recent advent of mini-fluorescent lamps, lighting fixtures were developed by the contractor that allow compact fluorescent lamps to replace incandescent lamps in emergency lighting, exit signs and other applications. This takes advantage of the longer lamp life and higher-efficiency characteristics common to fluorescent lamps.

A survey was made of the suitability of compact fluorescent lighting installations at five locations where these lamps were used in exit signs, office corridors, washrooms, service tunnels and rooms housing various types of equipment. The installations were assessed according to lamp life, light output, ease of installation, cost effectiveness and energy savings.

It was found that fluorescent lamps and fixtures are substantially more expensive than comparable incandescent units, but these costs are offset by savings owing to a longer (10X) lamp life and greater (4X) efficiency. Using typical electricity costs in Alberta, compact fluorescent lamps are cost-effective, energy-saving substitutes for continually operated incandescent lamps. In some downlighting situations, however, lumen output may be insufficient to meet building code requirements.

Users were satisfied with compact fluorescent fixtures and pointed out advantages such as the elimination of heat damage caused by incandescent lamps to exit sign enclosures, the reduced load on air conditioning systems and the fact that the service life of fluorescent lamps tended to be greater than the rated life indicated by manufacturers. The contractor concluded that compact fluorescent systems should be marketable as replacements for many existing incandescent systems.

The project has been completed.

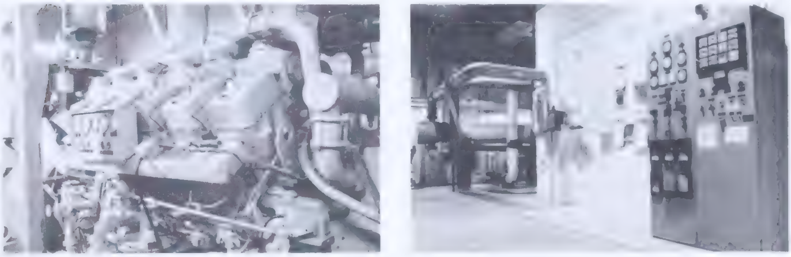
Peak Electrical Demand Reduction Through Co-generation

Cheriton Engineering Ltd., Calgary

One way that commercial users of electricity can reduce their energy costs is to lower their maximum (peak) demand for power. Because many large buildings already have an emergency generator on hand to be used during power failures, it was proposed that the generator could be used more often to produce some of the electricity needed in the building and thereby reduce peak demand. Also, the heat produced by the generator might be used to offset some requirements for purchased heat.

The operation of an existing 1 MW gas-fired co-generation unit at the University of Lethbridge is being studied to determine the cost effectiveness of using it to reduce demand peaks and recover useful heat. If appropriate, improvements are to be made to the system to optimize its performance.

Four potential changes to the equipment were identified, including the use of an exhaust heat recovery silencer to recover more heat, replacement of an existing single-speed motor on the outdoor radiator with a two-speed motor and a motorized damper controller, installation of a differential temperature controller and the use of a motorized valve at the heat exchanger discharge line. Two of these suggestions, however, were not recommended because their payback periods of seven years or more were considered excessive. Meanwhile, it was recognized that a considerably more sophisticated monitoring program was required than had been originally assumed. This caused some delay in the project.



At the University of Lethbridge, a 1 MW co-generator (left) and its sophisticated control system (right) are being monitored to determine the cost effectiveness of using the unit to reduce peak demands for electricity.

Wind Energy

Canada is one of the windiest countries on Earth, and one region where winds are ever present is southern Alberta; this makes it an ideal location for wind energy studies. Since 1977, three major wind energy studies have been supported, beginning with the Solar and Wind Energy Research Program (SWERP), which was concluded last year.

Concurrent with SWERP, a wind research site was established at Lethbridge where the performance characteristics of wind turbines are measured. Also, a unique delta-blade wind turbine was developed from a small, bench-scale model to a full-scale prototype unit.

This year, the delta-blade turbine project drew to a close. The turbine's performance characteristics and the latest results of turbine testing at the Lethbridge Wind Research Site are described in the following section.

Demonstration and Testing of Small-Scale Wind Turbines

Alberta Agriculture, Lethbridge

During annual demonstration days at the Lethbridge Wind Research Site, hundreds of visitors come to observe the variety of wind turbines undergoing testing.

The Lethbridge Wind Research Site has attracted international attention during the five years it has been operating. Since 1982, numerous wind turbines have been tested to determine their performance capabilities in pumping water under controlled and closely monitored conditions. Sales of wind turbines in Alberta and Saskatchewan increased as a result of the project and hundreds of prospective buyers have visited the facility. Manufacturers, too, appreciate the value of an independent test facility in evaluating wind turbine designs. In fact, test site operators are having some difficulty making space available to all the manufacturers who wish to have their turbines tested.

In this second year of a second three-year test period, the original data acquisition system was replaced with an IBM computer system, and the pump station, which stores and circulates water to the wind turbines, was overhauled. Then, eight wind turbines and two solar-powered water pumpers were installed and tested. Seven of the wind turbines are designed to pump water; the other unit generates electricity. An attempt was made to test the Deltx WP-20 and one other turbine during the winter, but the difficulties of coping with low temperatures made it impossible to obtain useful information.

Some meaningful trends are developing from this work. The overall system efficiency of wind turbines often suffers because of a poor match between the turbine and the water-pumping system. The contractor recommends that more research is needed to test a variety of pumping devices. Solar units are more reliable than wind turbines, but their capital costs and ability to pump only during daylight hours make them less cost effective than wind turbines. Research work is continuing.

A Large Delta-Blade Wind Turbine, an Alberta Development

Deltx Windpump Corporation, Calgary

Development work on the Deltx delta-blade wind turbine has been completed. The manufacturer is now marketing the WP-20, a 5 m (16 ft.) rotor diameter machine, shown here undergoing testing at the Lethbridge Wind Research Site.

This project began in 1981 with little more than some impressive wind tunnel test results on a unique wind turbine design that had been conceived by two University of Calgary engineers.

Over the next five years, a wind turbine using eight delta-blades fixed to a rotor evolved from a small model having a rotor diameter of 394 mm (15.5 in.) to a prototype of a commercial-scale machine which stands 31 m (103 ft.) above the ground and has a rotor diameter of 16 m (50 ft.). The machine, known as the Deltx WP-50, is designed to pump large volumes of water and has promising potential in such applications as water pumping for irrigation systems or hydroelectric projects.

This year, the final phase of product development — performance testing — was completed. An automated data logging system attached to the WP-50 collected information on turbine rotational speed, pump stroke length and water flow rate. It also measured wind speed and direction, ambient temperature and atmospheric pressure.

The data showed that at a head of 4.9 m (16 ft.) the WP-50 began pumping water at wind speeds as low as 2.2 m/s (5 m.p.h.). When the pumping head was 6.3 m (21 ft.) the water pumping rate reached 500 L/s (6 600 gal./min.) at a wind speed of 15 m/s (33 m.p.h.). Also, the performance data corresponded with predictions made in 1977, based on wind tunnel testing of the small-scale wind turbine.

To achieve a better position in the wind turbine marketplace, the contractor built a smaller unit, the WP-20, having a rotor diameter of 5 m (16 ft.). Its water-pumping characteristics were tested at the Lethbridge Wind Research Site. They were found to be superior to any of the 14 conventional, multi-bladed water-pumping wind turbines that had been tested previously.

The project is completed. The contractor is now marketing the WP-20. The performance-testing report is available for viewing at the Alberta Energy Library (see Appendix B).

Waste Heat Recovery/ Low Temperature Heat Utilization

In many industrial processes, as well as in commercial and institutional buildings, heat that is used for some purpose or is produced by chillers and compressors is eventually discharged through exhaust gases or effluent streams. This is a waste because this heat could be employed in some useful manner before it is lost to the environment.

In commercial laundries, for example, the dirty water left from washing is still warm when it is released to the sewer. In dairies, breweries and food-processing plants, where cold storage is required, unrecovered waste heat is produced by the refrigeration compressors. In each of these cases, opportunities exist to recover waste heat or low temperature heat and use it for some productive purpose.

Also, interest is growing in the use of co-generation systems to simultaneously produce electricity and heat for on-site use. This is another concept that might be appropriate in Alberta.

Investigating these opportunities is the primary objective of the Waste Heat Recovery/Low Temperature Heat Utilization subprogram, which supported seven projects this year. They are described in the following section.

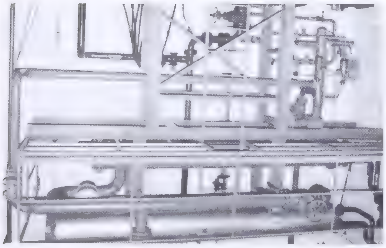
Heat Recovery in a Full-Service Dairy

Palm Dairies Ltd., Calgary

A detailed analysis of a Calgary dairy identified an opportunity to recover 20 per cent of the waste heat produced by the refrigeration system and use it to preheat process water. Subsequently, a heat recovery system was designed that is capable of saving approximately $21 000 a year in energy costs, with a three-year payback period. Before equipment could be ordered, however, the dairy was sold. This delayed any decisions to proceed with the project. Tenders were called for the retrofit work, but the completion date has been extended by nearly two years.

Heat Recovery in a Meat-Packing Plant

Lakeside Feeders Ltd., Brooks



Desuperheater (above) and condenser (below), installed at Lakeside Feeders Ltd. in Brooks, allow water temperature to rise by 25°C before the water is used in the abattoir.

Based on an energy audit of the contractor's operations, it was estimated that 25 per cent of the waste heat from the refrigeration system could be recovered and used in-house. Subsequently, a heat recovery system was designed that employed desuperheater and condenser heat exchangers to recover heat from the plant's cooling system and a water-circulating system to deliver the recovered warm water to the abattoir. A payback period of less than two years was projected.

The equipment was installed and commissioned. Initial results are promising. Not only is heat recovered as expected, but an unexpected bonus has been the reduced downtime and lower costs incurred before slaughtering periods because less time is required to start up the process water system. The heat recovery system will be monitored for one year. If current indications continue, the project should provide encouraging and interesting results for other meat-packing firms, breweries, dairies, vegetable packers and poultry processors.

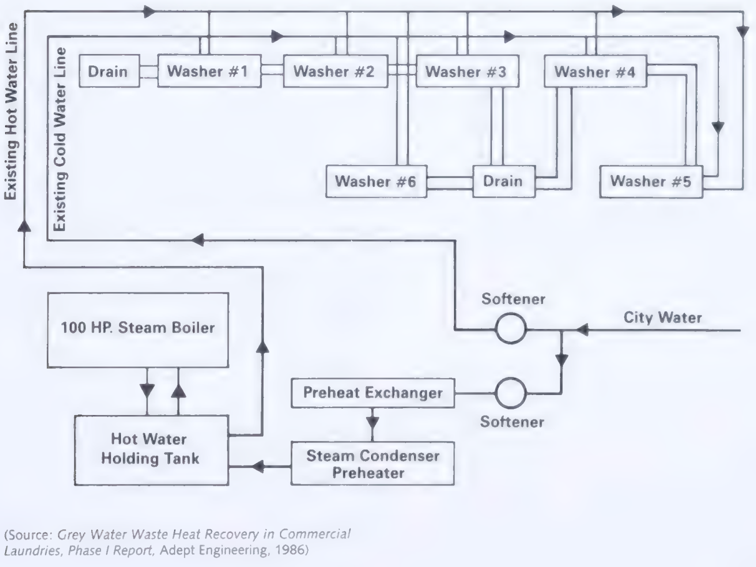
Grey Water Heat Recovery from Commercial Laundries

RTM Engineering Ltd., Calgary

The contractor has shown that heat contained in laundry process water, that is normally discharged to the sewer, can be recovered and used to preheat the wash water at two Calgary laundries. Although heat recovery schemes of this type are rare in Canada, the contractor installed the necessary heat exchange equipment and made appropriate revisions to the piping systems at both plants. It was estimated that payback periods would range from approximately two to four years for the two installations. Unexpected problems arose from plugging of the heat exchanger and other components with cloth fibres. Consequently, it became necessary to install filters and diversion gates in various effluent streams, which added to the capital costs of the project.

A one-year monitoring period is underway. If proven economically feasible, the concept could be applicable in more than 20 large Alberta laundries, with potential annual energy cost savings of approximately $700 000.

Schematic of Operations at Rosedale Linen Plant in Calgary Before Installation of a Heat Recovery System



(Source: *Grey Water Waste Heat Recovery in Commercial Laundries, Phase I Report*, Adept Engineering, 1986)

Waste Heat Recovery in a Recreation Facility

Kasten Eadie Engineering Ltd., Edmonton

The contractor investigated the feasibility of recovering waste heat from the exhaust gases of an ice-making refrigeration unit at the Okotoks Triplex Arena and using it to heat the pool water and/or supply some heat to the dressing rooms. During the technology review phase of the project, the contractor concluded that heat recovery of this sort might be applicable in two-thirds of the 560 artificial ice arenas in Alberta, but a detailed analysis of the Okotoks facility revealed that a payback period of eight years would be required. (Ice is available nine months of the year; if it were available year-round, the payback period could be reduced to six years). There was not sufficient financial incentive for the town of Okotoks to proceed; the project was terminated.

Co-generation Demonstration in Commercial Buildings

Northwestern Utilities Limited, Edmonton

Energy conservation, when practised widely, could help postpone the need for large and expensive electricity-generating stations. One option available to owners of commercial and institutional buildings is to install co-generation equipment to produce electricity on site, and use heat produced by the generator to replace some purchased energy.

The contractor reviewed the energy requirements of more than 50 prospective buildings within the company's service area and found 11 that were worthy of detailed analysis. Based on calculations of the simple payback period, internal rates of return, location, willingness to participate in a demonstration project and ease of equipment installation, an Edmonton dry-cleaning establishment was selected as a site where a co-generation unit might be installed and demonstrated. It was calculated that a 115 kW co-generator costing $105 000 should have a payback period of approximately five years if installed at this location. The contractor plans to begin negotiations with the owners of the dry-cleaning firm for installation, long-term operation and monitoring of a co-generation unit.

Co-generation Assessment Study

Southern Alberta Institute of Technology, Calgary

The 600 kW steam turbine at the Southern Alberta Institute of Technology is one of the systems being studied in an assessment of the cost effectiveness of co-generation in Alberta.

Co-generation, the simultaneous production of electric and thermal energy from a single fuel source, is capable of saving up to half the fuel that would be required to produce each form of energy separately.

In the first phase of this project, the contractor reviewed the existing co-generation technology and its cost effectiveness. Economic assessments indicate that co-generation systems could be used in situations where electricity demand is 500 kW or more and the thermal load is both consistent and high.

Computer simulations performed for a residential duplex, a restaurant and an office building showed promise for only the office building. This indicated payback periods of approximately five to seven years, depending on the type of co-generation equipment. It was concluded that the remainder of the study should focus on larger applications.

Utilization of Waste Heat for Crop Production

C.W. Reclamation Ltd., Olds

The original objective of this project was to distribute hot process water from a petrochemical plant through underground piping in an adjacent farm field and transfer heat to the soil, thereby extending the growing season and enhancing crop production. While an initial investigation of the concept revealed there were no technical obstacles to proceeding with installation of the system, the initial site chosen for the test was found to be unsatisfactory. Attempts to find alternative test sites having nearby sources of warm wastewater were unsuccessful. At year-end, the contractor was assessing another site to enable the project to continue.

Technology Transfer and Dissemination

MacKenzie Environmental Consultants Ltd., Edmonton

The pertinent findings of approximately 65 research projects supported by A/CERRF since 1976 are being summarized and published in a series of technology transfer booklets. While some booklets are devoted to individual projects, others cover several projects having a common theme.

By year-end, nine booklets on various energy conservation and renewable energy topics had been published and distributed to more than 300 energy researchers, government agencies, energy companies and technical libraries.

These publications are available from:

Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Bramalea Building
9920 - 108 Street
Edmonton, Alberta
T5K 2M4
Telephone: (403) 427-3590

Solar Energy Potential for Alberta, 9 pages, March 1986.

A Practical Method for Defouling Heat Exchangers, 6 pages, March 1986.

Development of a Krypton Fluoride Laser for Fusion Energy Research, 6 pages, July 1986.

Geothermal Energy Resources in Alberta, 10 pages, August 1986.

Measuring and Harnessing Alberta's Wind Resources, 10 pages, October 1986.

Energy Management in Commercial Buildings, 8 pages, December 1986.

Control of Heat Loss Associated with Overhead Doors, 6 pages, January 1987.

Practical Methods to Seal and Insulate Residential Buildings, 9 pages, March 1987.

Performance Characteristics of Energy-Efficient Furnaces, 9 pages, March 1987.

By year-end, nine technology transfer booklets on various energy conservation and renewable energy topics had been published and distributed.

Appendices

Financial information on this year's projects, as well as sums expended to date on all A/CERRF-funded energy conservation and renewable energy projects, can be found in Appendix A.

Research reports that have resulted from some of these investigations, and are available for viewing at Alberta Energy's library in Edmonton, are listed in Appendix B.

Appendix A: Summary of Program Expenditures

A/CERRF Energy Conservation and Renewable Energy Projects and Expenditures to Date

Subprogram Area and Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	Projected Future Funding	Projected Total Funding Contribution
General Energy Conservation												
Control of Energy Losses by Microbial Fouling of Heat Exchangers	-	23 768	67 628	3 999	-	-	-	-	-	-	-	94 795
Ice Nucleation Technique for Defouling of Heat Exchangers	-	-	-	-	75 459	4 799	-	-	-	-	-	80 258
Using Thermal Discharges from Power Plants	-	9 653	5 347	-	-	-	-	-	-	-	-	15 000
Fuel and Fertilizer Production from Dairy Manure	-	6 176	17 148	-	-	-	-	-	-	-	-	23 324
Efficient Use of Low Heating Value Fuels	-	-	11 984	32 064	15 772	-	-	-	-	-	-	59 820
Streamline Device for Transport Trucks	-	-	665	5 995	2 256	-	-	-	-	-	-	8 916
Energy from Waste Wood (Sawmill Residues)	89 094	7 917	15 844	1 646	-	-	-	-	-	-	-	114 501
Efficiency of Rotary Piston Engine	9 213	2 644	-	-	-	-	-	-	-	-	-	11 857
District Heating Study	-	66 394	33 606	(6 600)	-	-	-	-	-	-	-	93 400
Energy Conservation in Sour Gas Processing	146 927	196 536	268 323	97 256	209 532	34 963	93 637	131 400	-	-	-	1 178 574
Subtotal — General Energy Conservation	**245 234**	**313 088**	**420 545**	**133 760**	**303 019**	**39 762**	**93 637**	**131 400**	-	-	-	**1 680 445**
Solar Energy												
Copper-Oxide Solar Cells	-	8 404	20 466	-	-	-	-	-	-	-	-	28 870
An Atlas of Solar Energy for Alberta	-	-	23 730	17 884	3 015	-	-	-	-	-	-	44 629
Application of Boiling and Condensation Heat Transfer for Flat Solar Collectors in Cold Regions	-	-	27 237	33 359	25 627	12 977	-	-	-	-	-	99 200
An Air-Mediated Solar Heating System with Long-Term Storage	-	-	15 706	26 907	-	-	-	-	-	-	-	42 613
An Advanced Control Approach for Solar Heating Systems	-	-	-	-	10 219	3 621	-	-	-	-	-	13 840
Subtotal — Solar Energy	-	**8 404**	**87 139**	**78 150**	**38 861**	**16 598**	-	-	-	-	-	**229 152**
Geothermal Energy												
Research on Alberta's Geothermal Energy Resources	-	18 063	43 286	75 298	60 399	83 704	57 463	-	-	-	-	338 213
Fusion Energy												
Laser Fusion Energy Research	-	5 784	56 111	122 995	144 855	152 927	146 987	-	-	-	-	629 659

Subprogram Area and Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	Projected Future Funding	Projected Total Funding Contribution
Energy Conservation in Buildings												
Alberta Home Heating Research Facility	-	2 825	142 705	44 740	33 990	19 524	-	-	-	-	-	243 784
Insulation Properties of Flat Built-Up Roofs	-	19 268	6 584	13 930	8 176	7 980	-	-	-	-	-	55 938
Passive Solar-Heated Community Centre	-	-	-	2 050	10 120	2 000	-	-	-	-	-	14 170
Energy-Efficient Masonry Fireplaces	-	-	-	-	-	48 820	-	-	-	-	-	48 820
Edmonton Energy Conservation Centre	-	-	-	-	-	-	-	51 920	25 000	-	-	76 920
Self-Help Retrofit Manual for Owners of Multi-Family Housing Units	-	-	-	-	-	-	1 745	12 805	10 850	-	-	25 400
Retrofit Wall Systems for Residential Housing	-	-	-	-	-	-	342	2 540	6 998	-	-	9 880
Energy Savings and Payback of Retrofit Basement Wall Insulation	-	-	-	-	-	-	506	8 435	3 883	-	-	12 824
Energy-Efficient Housing Display Program	-	-	-	-	221 332	3 614	3 384	2 650	-	3 020	-	234 000
Townhouse Retrofit Demonstration	-	-	-	-	-	-	6 477	11 049	2 514	-	-	20 040
A Survey of Air Leakage in Alberta Homes	-	-	-	-	-	-	15 709	40 071	4 376	-	-	60 156
Construction and Testing of a Masonry Module	-	-	-	-	-	-	9 931	15 237	5 896	-	-	31 064
Concrete Masonry Walls for Thermal Storage, Heating and Insulation	-	-	-	-	-	-	5 860	10 440	(1 630)	-	-	14 670
Computer Program for Analysis of Thermal Mass	-	-	-	-	-	-	-	-	24 314	1 641	-	25 955
Sizing of Warm Air Furnaces for Residential Use	-	-	-	-	-	-	3 192	127	-	-	-	3 319
Development of Higher-Efficiency Gas-Fired Furnaces	-	-	-	-	-	-	4.387	35 624	30 000	-	-	70 000
Seasonal Efficiency of Residential Natural Gas Furnaces	-	-	-	-	-	-	-	20 261	12 738	1 190	-	34 189
Development of an Insulating Curtain for Residential Installation	-	-	-	-	-	-	8 047	25 917	-	-	-	33 964
Residential Air-to-Air Heat Exchanger Using Heat Pipe Technology	-	-	-	-	-	-	943	5 968	4 192	1 448	-	12 551
Energy Conservation in Public Swimming Pools	-	-	-	-	-	-	9 969	20 236	1 635	-	-	31 840
Development of a User-Friendly Computerized Building Management System	-	-	-	-	-	-	4 928	37 281	26 914	477	-	69 600
Multi-Zone Setback Thermostat	-	-	-	-	-	-	8 359	28 553	4 048	-	-	40 960

Subprogram Area and Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	Projected Future Funding	Projected Total Funding Contribution
A New Heat-Conserving Control System for Warehouse-Type Buildings	-	-	-	-	-	-	3 538	17 782	9 654	-	-	30 974
Demonstration of a Cost-Effective Energy Management System	-	-	-	-	-	-	8 427	8 359	-	-	-	16 786
A Ventilation Control System Based on Carbon Dioxide Levels	-	-	-	-	-	-	604	750	-	-	-	1 354
Inventory of Building Design and Analysis Computer Programs and a Weather Input Data Base for Alberta	-	-	-	-	-	-	1 484	36 063	-	-	-	37 547
Energy-Efficient Fluorescent Lighting Ballast	-	-	-	-	-	-	19 565	30 371	-	-	-	49 936
Computer Simulations for Mechanical Systems in Buildings	-	-	-	-	-	-	8 886	27 885	11 538	-	-	48 309
Programmable Controller for Parking Lot Block Heater Service	-	-	-	-	-	-	-	-	7 554	2 868	-	10 422
Comprehensive Retrofit Measures in Commercial Buildings	-	-	-	-	-	-	-	-	14 552	-	-	14 552
Retrofit Curtain for Overhead Doors	-	-	-	-	-	-	-	-	13 656	3 493	-	17 149
Demonstration of Mini-Fluorescent Lighting	-	-	-	-	-	-	-	-	2 700	3 235	-	5 935
Survey of Energy-Efficient Furnaces	-	-	-	-	-	-	-	-	20 282	14 167	-	34 449
Swimming Pool Dehumidification Demonstration	-	-	-	-	-	-	-	-	4 700	20 234	2 766	27 700
Peak Electrical Demand Reduction Through Co-generation	-	-	-	-	-	-	-	-	5 745	8 376	17 515	31 636
Demonstration of Free Cooling in Building Humidification Systems	-	-	-	-	-	-	-	-	2 600	15 323	15 647	33 570
Demonstration of Low Emissivity Ceilings in Alberta Arenas	-	-	-	-	-	-	-	-	8 102	28 517	2 229	38 848
Subtotal — Energy Conservation in Buildings	**-**	**22 093**	**149 289**	**60 720**	**273 618**	**81 938**	**126 272**	**450 324**	**262 811**	**103 989**	**38 157**	**1 569 211**
Wind Energy												
Comparison of Wind Turbines	-	-	-	-	10 686	14 310	-	-	-	-	-	24 996
Demonstration and Testing of Small-Scale Wind Turbines	-	-	-	-	-	72 386	47 324	34 408	61 974	46 938	40 000	303 030
Solar and Wind Energy Research	131 731	539 332	310 813	256 673	334 809	233 699	254 195	237 605	187 681	-	-	2 486 538
A Large Delta-Blade Wind Turbine, An Alberta Development	-	-	-	-	92 945	170 400	477 772	35 294	108 222	39 778	-	924 411
Subtotal — Wind Energy	**131 731**	**539 332**	**310 813**	**256 673**	**438 440**	**490 795**	**779 291**	**307 307**	**357 877**	**86 716**	**40 000**	**3 738 975**

Subprogram Area and Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	Projected Future Funding	Projected Total Funding Contribution
Waste Heat Recovery/Low Temperature Heat Utilization												
Grey Water Heat Recovery from Commercial Laundries	-	-	-	-	-	-	-	-	36 906	72 949	-	109 855
Heat Recovery in a Recreation Facility	-	-	-	-	-	-	-	-	5 707	-	-	5 707
Heat Recovery in a Meat-Packing Plant	-	-	-	-	-	-	-	-	14 089	47 956	10 294	72 339
Heat Recovery in a Full-Service Dairy	-	-	-	-	-	-	-	-	12 912	1 267	38 541	52 720
Co-generation Demonstration in Commercial Buildings	-	-	-	-	-	-	-	-	1 267	12 098	92 496	105 861
Co-generation Assessment Study	-	-	-	-	-	-	-	-	14 758	16 244	48 998	80 000
Utilization of Waste Heat for Crop Production	-	-	-	-	-	-	-	-	16 395	-	-	16 395
Subtotal — Waste Heat Recovery/Low Temperature Heat Utilization	-	-	-	-	-	-	-	-	**102 034**	**150 514**	**190 329**	**442 877**
TOTAL — Energy Conservation and Renewable Energy	**376 965**	**906 764**	**1 067 183**	**727 596**	**1 259 192**	**865 724**	**1 203 650**	**889 031**	**722 722**	**341 219**	**268 486**	**8 628 532**
Technology Transfer	-	-	-	-	-	-	-	-	-	81 203	200 000	281 203
TOTAL	**376 965**	**906 764**	**1 067 183**	**727 596**	**1 259 192**	**865 724**	**1 203 650**	**889 031**	**722 722**	**422 422**	**468 486**	**8 909 735**

Appendix B: Publications List

The following project reports, prepared by contractors whose investigations were supported by A/CERRF, are available for viewing at:

Alberta Energy Library
9th Floor, South Tower, Petroleum Plaza
9915 - 108 Street
Edmonton, Alberta
T5K 2C9
Telephone: (403) 427-7425

General Energy Conservation

Thermal Power Plant Waste Heat Utilization in Alberta: Potential and Problems, F.B. MacKenzie and A.H. Laycock, University of Alberta, 1979.

Fuel and Fertilizer Production from Dairy Manure, J.J.R. Feddes, J.B. McQuitty and J.T. Ryan, University of Alberta, March 1980.

The Efficient Utilization of Low Heating Value Fuels, G.A. Karim, University of Calgary, January 1982.

A Streamline Device for Trucks and Buses, R.P. McKenzie, 1982.

Claus Plant Waste Gas Incinerators, Western Research and Development, July 1978.

Capability of the Modified Claus Process, H.G. Paskall, Western Research and Development, 1979.

Catalytic Incineration of Sulphur Plant Waste Gases, Bow Valley Research Ltd., February 1981.

Recuperative Heat Exchange Incinerator Pilot Plant, Bow Valley Research Ltd., October 1981.

Study on Energy and Chemicals from Wood, SNC Tottrup Services Ltd., 1979.

Edmonton District Heating Study — Financial Feasibility, Stanley Associates Engineering Ltd./Ekono Engineering Consultants, February 1980.

An Energy Audit Strategy for Gas Plants, Bow Valley Research Ltd., June 1985.

Solar Energy

A Solar Energy Atlas for Alberta, Volumes I and II, L.C. Nkemdirim, University of Calgary, September 1981.

Application of Boiling and Condensation Heat Transfer to Flat Plate Solar Collectors in Cold Regions, K.C. Cheng, University of Alberta, August 1982.

Study of Air-Mediated Solar Heating Systems with Long-Term Storage, A.M. Robinson, University of Alberta, April 1981.

A Study of Improved Control Strategies for Bilinear Heat Transfer Processes in a Solar-Assisted Heat Pump System, R.E. Rink and H.Q. Le, University of Alberta, October 1982.

Solar and Wind Energy Research Program (SWERP) Information Centre, Alberta Research Council, March 1986.

Geothermal Energy

An Investigation of Geothermal Energy Resources of Alberta, F.W. Jones, H.L. Lam and T.N. Nasr, University of Alberta, October 1981.

A Detailed Study of Regions of Geothermal Energy Potential in Alberta, F.W. Jones, H.L. Lam, M. Rahman and D. Yuen, University of Alberta, October 1982.

A Preparatory Study for Application of Geothermal Energy in the Hinton/Edson Area of Alberta, F.W. Jones, M. Rahman, H.L. Lam and J.E. Sworder, University of Alberta, October 1983.

Fusion Energy

CO_2 Laser-Heated Solenoid Research and High Power Krypton Fluoride Laser Development for Fusion Energy Research, A.A. Offenberger, D.C.D. McKen and R. Fedosejevs, University of Alberta, May 1981.

High Power Krypton Fluoride Laser Development for Fusion Energy Research, A.A. Offenberger, D.C.D. McKen and R. Fedosejevs, University of Alberta, May 1983.

Energy Conservation in Buildings

Construction of the Alberta Home Heating Research Facility and Results for the 1979-1980 Heating Season, R.R. Gilpin, J.D. Dale, T.W. Forest and M.Y. Ackerman, University of Alberta, August 1980.

Second Annual Report on the Alberta Home Heating Research Facility: Results for the 1980-81 Heating Season, R.R. Gilpin, T.W. Forest, M.Y. Ackerman, D.G. Wilson, G.W. Sadler, J.D. Dale and M. Zaheeruddin, University of Alberta, June 1981.

A Simulation Model for a Direct Gain Passive House and its Experimental Verification, M. Zaheeruddin, University of Alberta, April 1983.

A Study of Residential Housing Envelope Heat Losses, M.Y. Ackerman, University of Alberta, April 1983.

Thermal Performance of an Insulated Masonry Structure: Results of the 1983-84 Heating Season, L.W. Kostiuk and J.D. Dale, October 1984.

The Attachment of Insulation to Existing Built-Up Roofs, Alberta Roofing Contractors, August 1981.

A Project to Build and Display Energy-Efficient Single Family Homes in Alberta, HUDAC Alberta Council, November 1982.

Report on the Selection of Warm Air Furnaces for Residential Housing, J.E. Sworder Engineering, November 1984.

Report on Inventory of Computer Programs, Vinto Engineering Ltd., December 1984.

Report on Development of an Alberta Weather Input Data Base, Vinto Engineering Ltd., February 1985.

R&D of an Insulating Curtain for Residential Application, Sunergy Systems Ltd., April 1985.

The Edmonton Energy Conservation Centre — Phase I Retrofit, Tomorrow Foundation, May 1985.

Edmonton Energy Conservation Centre, Phase II Final Report, Brian Staszenski, March 1986.

Technical Feasibility and Cost Study of Programmable Controller for Parking Lot Block Heater Services, Magna IV Engineering Ltd., November 1985.

Programmable Controller for Parking Lot Block Heater Services, Magna IV Engineering Ltd., March 1986.

Demonstration of Low Emissivity Ceilings in Arenas, Phase I, Sunton Engineering Ltd., April 1986.

Demonstration of Low Emissivity Ceilings in Arenas, Phase II, Sunton Engineering Ltd., September 1986.

A Survey of Air Leakage in Calgary Homes, Bill Johnston Architect Ltd., April 1986.

A Study of the Performance of Six Residential Natural Gas Furnaces, J.F. Kasha and J.D. Dale, University of Alberta, May 1986.

Cost-Effective Energy Management System, Whitaco Holdings Ltd., June 1986.

Survey of Medium- and High-Efficiency Gas Furnaces, W.J. Mayhew and D.G. Howell, Howell Mayhew Engineering Inc., December 1986.

Development of a Computer Program for Analysis of Thermal Mass in Buildings, A.P. Byrne and T.G. Lee, University of Calgary, December 1986.

Energy Savings and Payback with Basement Wall Insulation Retrofit, D.S. Greeley, Dow Chemical Canada Inc., December 1986.

Retrofit Wall System for Residential Housing, J. Ostrowski and H. Ostrowski, ARE–Alternative and Retrofit Energies Inc., January 1987.

Wind Energy

Evaluation of Low Volume Wind Turbines for Pumping Water, B.A. Paterson, D.R. Baker and N.E. Jensen, 1985.

Comparison Study of Wind Turbines, The Dalcor Group, April 1982.

Survey of Wind Turbine Installations in Alberta in 1981, D.R. Baker, DRB Engineering Consultants Ltd., April 1986.

Performance Test Results of the Deltx WP50 Windpump Prototype, D.R. Baker, DRB Engineering Consultants Ltd., September 1986.

Waste Heat Recovery

Waste Heat Recovery in a Meat-Packing Plant, Phase I, Crawford Consulting Engineering Ltd., December 1985.

Additional copies of this review are available from:
Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Bramalea Building
9920 - 108 Street
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